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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
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Cover: Freshly emerged Footman Moth *Nepita conferta* from the cocoon on a brightly painted wall in the Nilgiris. Digital art on Procreate. © Aakanksha Komanduri.

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COMMUNICATION

Population dynamics and habitat preference in Painted Stork *Mycteria leucocephala* and Woolly-necked Stork *Ciconia episcopus* in Dighal Wetland, Jhajjar, Haryana, India

Sony [1] & **Sarita Rana** [2]

[1] Department of Zoology, Kurukshetra University, Kurukshetra, Haryana 136119, India.
[2] Department of Zoology, Institute of Integrated and Honors Studies, Kurukshetra University, Kurukshetra, Haryana 136119, India.
[1] sonynayyar2000@gmail.com (corresponding author), [2] saritarana20@gmail.com

Abstract: The current study looks at the Painted Stork *Mycteria leucocephala* and Woolly-necked Stork *Ciconia episcopus* populations and their habitat utilization in the wetlands of Dighal, Haryana. The distribution and abundance of both species were evaluated through field surveys in various wetland habitats. The findings show that the Painted Stork population exhibited considerable habitat fluctuation, indicating a strong preference for specific wetland locations that offer the best chances for foraging and breeding. The range of the Woolly-necked Stork, on the other hand, was comparatively consistent throughout various habitats, suggesting a wider ecological tolerance. Painted Stork was most commonly observed in wetlands, whereas Woolly-necked Stork was observed in marshes and dry areas. Among the different habitats, the highest number of individuals of Painted Stork (7.41 ± 1.83) was seen in wetland, and Woolly-necked Stork (0.75 ± 0.37) was seen in agricultural land. The lowest number of individuals of Painted Stork (2.66 ± 0.69) was seen in barren land, and Woolly-necked Stork (0.66 ± 0.35) was seen in wetland. These results demonstrate importance of preserving Dighal's varied wetland habitats to sustain both specialized and generalist stork species and further knowledge of their ecological needs in a constantly shifting landscape.

Keywords: Anthropogenic activities, coexistence, conservation, line transect method, point count method, seasonal variation, species abundance, vegetation, waterbirds, wetland ecology.

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Author details: Sony is currently pursuing Ph.D. degree at Kurukshetra University, Kurukshetra, working on the comparative ecology of Painted Stork and Woolly-Necked Stork at Gurugram and Jhajjar District, Haryana. Her research focus is on animal behaviour and wildlife, mainly on storks. Sarita Rana is currently working as an associate professor in the Department of Zoology, Institute of Integrated & Honors Studies, Kurukshetra University, Kurukshetra. Her keen research interests include ecology and ornithology.

Author contributions: First author (S) has collected data, analyses the data and give this data a form of rough manuscript. Second author (SR) designed the study along with the first author and give the rough draft a final manuscript form.

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INTRODUCTION

There are 20 species of storks in the world, the majority of which are found in tropical or subtropical regions. With 20 living species, storks are a prominent pan-global freshwater flagship taxon listed on the IUCN Red List (Gula et al. 2023). This study concentrates on the Painted Stork *Mycteria leucocephala* Pennant, 1769 and Woolly-necked Stork *Ciconia episcopus* Boddaert, 1783, two of the least researched water-bird species worldwide (Sundar 2020). Both the species Painted Stork and Woolly-necked stork are large wading birds that belong to the family Ciconiidae under the order Ciconiiformes, found in India and southeastern Asia (Kalam & Urfi 2008), inhabit a variety of habitats including marshes, woods, agricultural regions, and freshwater wetlands (Sundar 2006; Kittur & Sunder 2021). The Painted Stork is distinguished by its colourful plumage, which consists of black, white, and a characteristic pinkish tint on its wings. Males and females are largely similar in appearance because there is little sexual dimorphism in this species. Males often have longer wingspans and more body mass than females, making them slightly larger (Kalam & Urfi 2006; Jangra & Verma 2024). Studies have shown that Painted Stork exhibit a strong preference for natural wetlands over rice fields and irrigation canals across seasons (Sundar 2006). While wetland saw relatively few Woolly-necked Stork sightings, with the majority being in agricultural fields (Kittur & Sunder 2020; Sundar 2020). Woolly-necked Stork is characterized as a single species of forest-nesting stork (Sundar 2020). The Painted Stork is listed as 'Least Concern' whereas the Asian Woolly-necked Stork conservation status is currently regarded as 'Near Threatened' on the IUCN Red List (IUCN 2025). The colonial nester Painted Stork is widely distributed in Sri Lanka and India (Tiwary & Urfi 2016). Woolly-necked Storks are solitary nesters that perch atop telephone towers, cliffs, and trees (Roshnath & Greeshma 2020). India is home to many Painted Storks which breed in mixed colonies and build their nests on trees that grow on islands in marshes, village tanks, urban water bodies, and parks (Tiwary & Urfi 2016; Byju et al. 2025). Woolly-necked Storks often exhibit seasonal migrations throughout the summer months in other parts of southern Asia (Sundar 2020). Numerous biological and environmental elements, including vegetation types, aquatic life, climate, and water quality, have a significant impact on the species diversity and population density of birds in wetland conditions (Bhawnani et al. 2025). Although there are regional variations in the species' population, habitat loss, pollution, and human activities pose dangers to it (Sundar 2020; Bhawnani et al. 2025). The composition and activities of wetlands are particularly impacted by urbanization. Urban wetlands offer vital habitat for birds and significant ecosystem services in an ecologically altered landscape, despite their simplified shape and diminished function (Suryawanshi & Sundar 2019; Kumar et al. 2025). The purpose of the study is to evaluate the two species' populations and distribution patterns, paying special attention to habitat usage and species-specific preference. Dighal Wetland is an ecologically significant location for these water-birds to forage and roost, as evident by the data showing notable variations in abundance across months and wetland microhabitats. The results of this study help to influence wetland management methods and provide useful baseline data for tracking conservation status. To protect the species, effective conservation measures are essential, especially since human pressures are still endangering their natural habitats. The development of conservation strategies for these species is urgently needed because of the extreme stresses on their habitat (Kalam & Urfi 2008).

MATERIALS AND METHODS

Study Area

The current study was conducted in the village of Dighal, Jhajjar District. The entire area of the state of Haryana is 1,834 km^2, of which 670 km^2 are dedicated to agricultural land (Anjali & Rana 2021). Dighal Wetland covers a total area of 131.1 ha (Parul & Kumar 2023, 2024). It is located in the north-west of the state of Haryana, 20 km from the district headquarters and 70 km from Delhi. The villages of Sampla to the east, Kalanaur to the west, Rohtak to the north, and Jhajjar to the south encircle it (Soni & Rana 2023). The district has a subtropical climate with four distinct seasons: summer (May–July), autumn (August–October), winter (November–January), and spring (February–April). The climate in district of Jhajjar is frigid in the winter and scorching in the summer. This area receives roughly 577 mm of annual rainfall, with the monsoon season accounting for over 75% of that total (Anjali & Rana 2022). Village Dighal was declared a potential Important Bird and Biodiversity Area (IBBA) (IN-HR-06) by BirdLife International (Anjali & Rana 2024). The Dighal wetland is suitable for migratory birds in the winter because they are encircled by irrigated agricultural fields with wheat and paddy crops, as well as tree species like Safeda (*Eucalyptus* spp.), Kikar (*Acacia* spp.), and Ber (*Ziziphus*

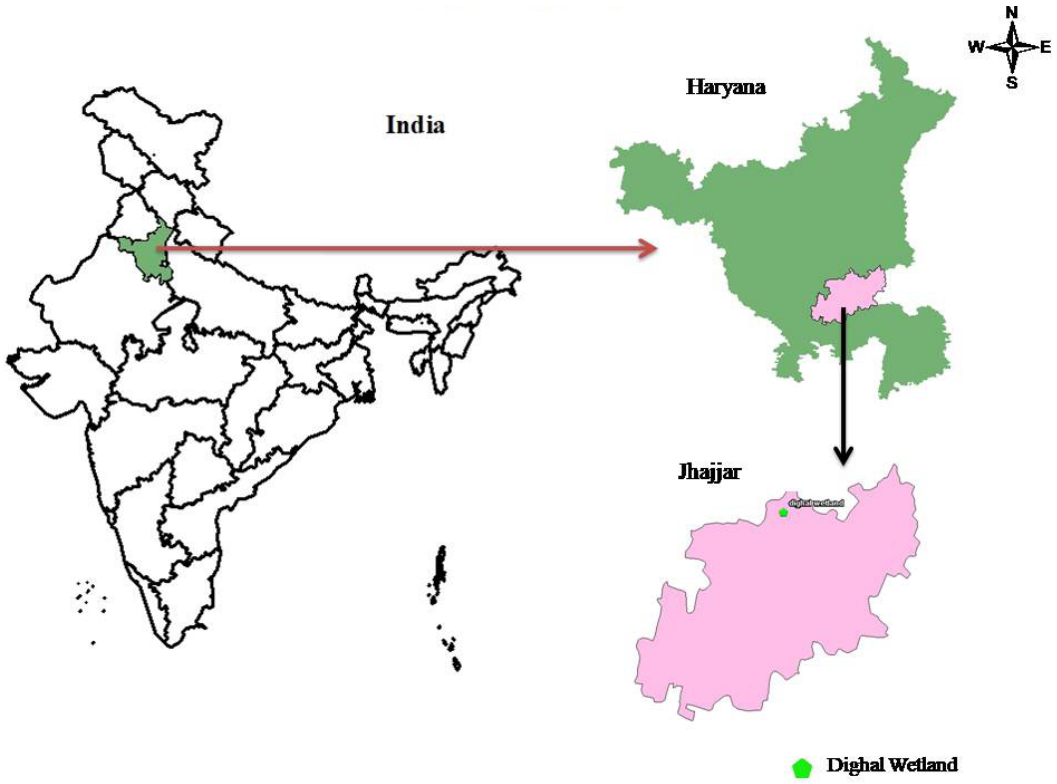

Figure 1. Map of study area showing location of Dighal Wetland, Jhajjar, Haryana, India.

spp.) along the wetland edges (Parul & Kumar 2023).

Bird Survey

The field visits were carried out from August 2024 to July 2025, twice a month. To assess the population dynamics of Painted Stork and Woolly-necked Stork**,** the point count and line transect methods were employed, depending on habitat openness and accessibility. Nikon Coolpix digital camera P950 and Nikon 10x50 binoculars were used for all observations. The study area was chosen after a reconnaissance survey, which involved preliminary visits to different wetland habitats in Dighal to assess habitat characteristics, bird presence, and anthropogenic activities. Based on these observations, Dighal Wetland was chosen for a detailed study of the Painted Stork and Woolly-necked Stork.

The point count locations were selected at fixed spots distributed across wetland's different habitats (open water, marshland, and agricultural areas) with broad visibility for 10 minutes, recording all individuals within a 100 m radius between 0600–1800 h in good weather. With this approach, all habitat types were covered, allowing for a reliable assessment of bird abundance. We observed species, their behaviour, and habitat. In dense or complex vegetation area, transects of 500–700 about 500 m to 1.5 km were laid to observe the storks, recording birds seen within 250 m and estimating their perpendicular distance. This combined approach ensured comprehensive coverage across diverse microhabitats for an accurate assessment of stork abundance and distribution. It is an easy technique that offers a consistent way to count birds throughout time or in different places. Randomly assigned point counts can serve as representative samples over a vast area. In order to verify the habitat composition for ground truthing, a single GPS location was recorded for each flock. Painted Stork and Woolly-necked Stork were recorded within 250 m on both sides of transect (Anjali & Rana 2024) (Figure 2).

Ecological studies employ the line transect method as a sampling approach to determine the distribution and abundance of species in various habitats. The population data for both storks were shown as mean ± standard error (SE). Using the one-way analysis of variance (ANOVA), the populations of Painted Stork and Woolly-necked Stork were compared at several locations. IBM SPSS 23 Software was used for all statistical analyses (Table 1).

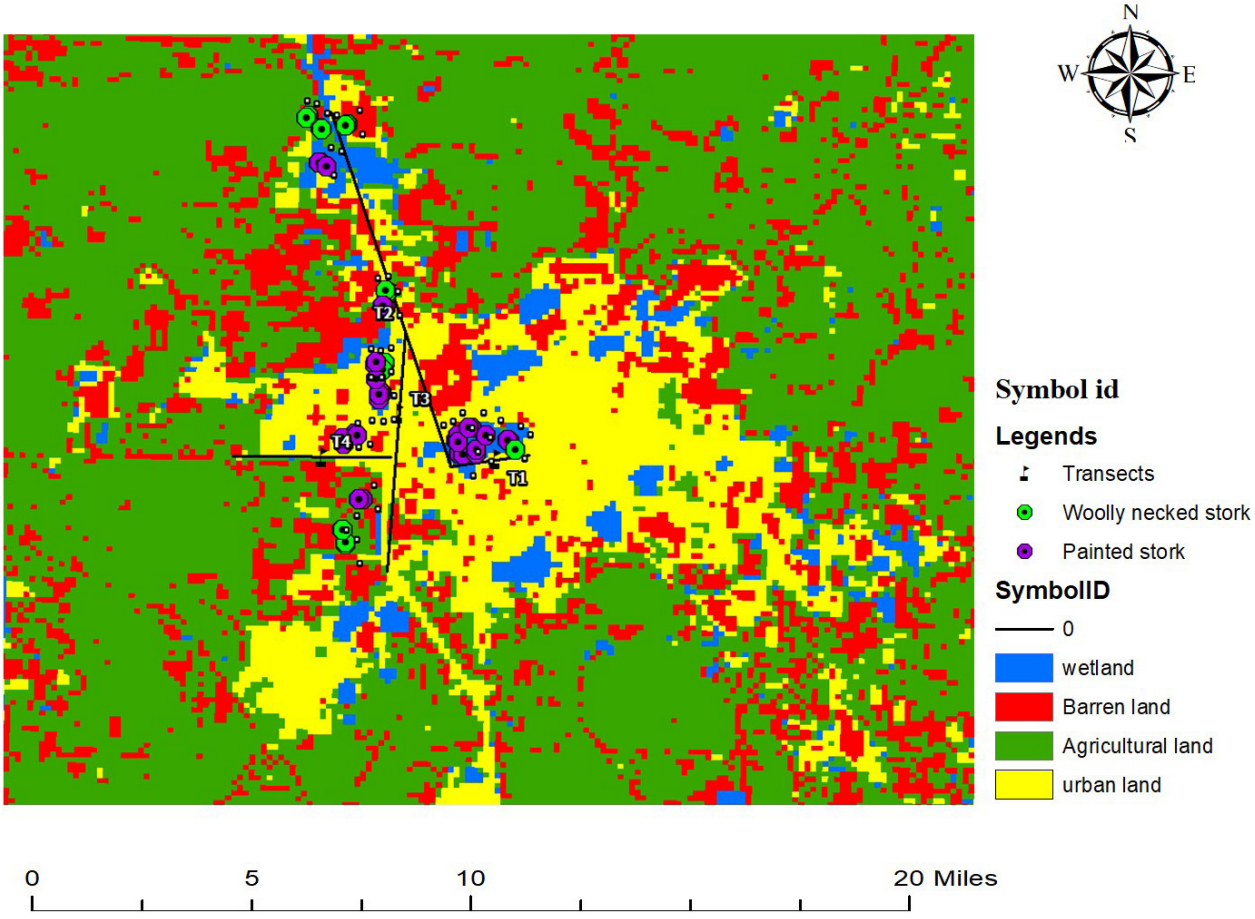

Figure 2. LULC map showing different habitat composition in Dighal Wetland.

RESULTS

In this study, a total of 169 Painted Storks and 31 Woolly-necked Storks were observed from the distinct habitats. Painted Storks were mostly recorded from Wetlands, followed by agricultural, and barren land. On the other hand, Woolly-necked Storks were dominant in marshes and arid areas (Figure 2). Among the different habitats, the highest number of individuals of Painted Stork (7.41 ± 1.83) was seen in the wetland and Woolly-necked Stork (0.75 ± 0.37) was observed in agricultural land. The lowest number of individuals of Painted Stork (2.66 ± 0.69) was seen in barren land and Woolly-necked Stork (0.66 ± 0.35) was seen in wetland, respectively. The habitat-wise population of Painted Stork varies significantly ($P < 0.05$), whereas that for Woolly-necked Stork shows no statistically significant difference ($P > 0.05$) (Table 1). Population abundance of Painted Stork was found to be significantly greater in wetland habitat ($P < 0.05$, $F = 3.78$) as compared to agricultural and barren landscapes; similarly, the population of Woolly-necked Stork was also found to be significantly greater in agricultural land area ($P > 0.05$, $F = 0.61$) as compared to other habitats, as shown in Table 1. During August 2024–July 2025, there was a discernible seasonal change in the Painted Stork and Woolly-necked Stork abundance. The winter months (December to February) had the maximum numbers of both species, peaking in mid-December. There was significantly more Painted Stork (84.5%) than Woolly-necked Stork (15.5%). On the other hand, lesser abundance of both species was observed in the summer season (May to July). From October to December, when the migratory season began, a steady rise in population (i.e., total number of individuals recorded in each habitat type) was observed (Figure 3).

DISCUSSION

The current study highlights the distinct ecological distinctions between the Painted Stork and Woolly-

Table 1. Habitat-wise population of Painted Stork and Woolly-necked Stork from August 2024 to July 2025.

Habitat	Painted Stork				Woolly-necked Stork			
	N	%	Mean ± standard error	95% CI (Min–Max)	N	%	Mean ± standard error	95% CI (Min–Max)
Wetland	89	52.66%	7.41 ± 1.83	2.00–24.00	8	25.80%	0.66 ± 0.35	0.00–4.00
Agricultural land	48	28.40%	4.00 ± 0.95	1.00–13.00	14	45.16%	0.75 ± 0.37	0.00–4.00
Barren land	32	18.93%	2.66 ± 0.69	0.00–9.00	9	29.03%	1.16 ± 0.29	0.00–3.00
P-value	0.03				0.59			
F-value (F)	3.78				0.61			

N—Total number of observations | CI—Confidence interval. All values are presented in mean ± standard error by one-way ANOVA, significant level at (P <0.05).

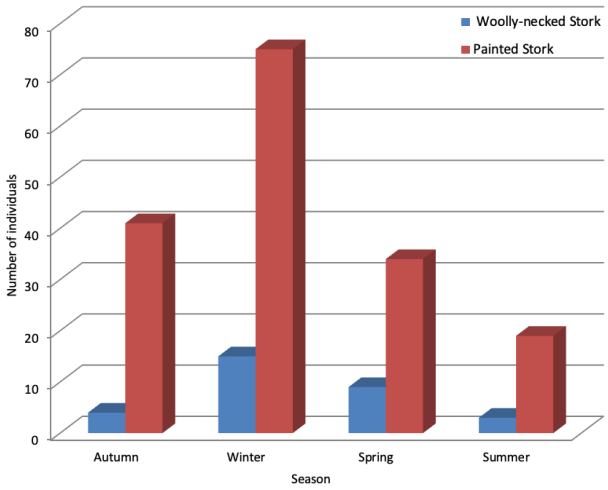

Figure 3. Showing Seasonal variations in population of Painted Stork and Woolly-necked Stork across one yearat the study area.

necked Stork in the Dighal Wetland, Haryana. The current study demonstrated distinct seasonal changes in the Painted Stork and Woolly-necked Stork populations at Dighal Wetland. In addition to migratory movement from other areas, the availability of open water and foraging grounds during this season may be the reason for the greater winter abundance of Painted Storks. Painted Stork was more commonly found in areas around and near waterbodies and open marshes, while the Woolly-necked Stork usually used agricultural fields, shallow ditches, and canal sides. This variation in how habitat is used could be a result of differences in foraging tactics, prey availability, and preferred water depth. The ready availability of fish and other aquatic prey in shallow waters is probably the reason why the Painted Stork preferred wetlands (Zakaria et al. 2023; Bhawnani et al. 2025), consistent with findings of this study. The Woolly-necked Stork, on the other hand, exhibits its adaptation to human-modified ecosystems by using natural and agricultural habitats (Kittur & Sundar 2021), a finding supported by this study. The two species may coexist more easily and compete less if their habitats are segregated. A species-specific approach to foraging and habitat selection is shown by the Woolly-necked Stork, particularly for peripheral areas like ditches and agricultural fields. The greater number of Painted Storks and Woolly-necked Storks were found in wetland habitat and agricultural land, respectively**.** Whereas smallest number of Painted Storks were found in agricultural land and barren land and Woolly-necked Stork were found in wetland and barren land. This study shows that by using different areas of waterbodies, Painted Stork is extremely suited to life in urban wetland. Furthermore, the study's findings show that Painted Storks favour areas with fewer human disturbances and predatory risks, which ensure a secure foraging and breeding environment, and help to sustain the species' population (Zakaria et al. 2023), a supporting observation with this study. According to rough population estimates, the extent of this species (Woolly-necked Stork) population was previously underestimated, and the greatest known global population of this species lives in agricultural environments (Kittur & Sunder 2020). The present findings also agree with the earlier research which indicated that flock size and habitat utilization varied significantly by season and location, and Woolly-necked Stork are also adaptable to shifting conditions on agricultural landscapes (Kittur & Sunder 2020). Storks may have been drawn to canals because of the decreased human use of irrigation canals and the small wetlands that formed alongside them from water escaping the canals. Furthermore, canals had longer hydroperiods than most marshes, whereas wetlands were highly seasonal (Kittur & Sundar 2021).

Both the Storks face several significant threats, including the degradation of feeding habitats, overfishing in key wetlands, and deforestation that impacts the availability of nest-building trees (Jangra & Verma 2024;

Image 1. Woolly-necked Stork: A—wetland | B—agricultural land | C & D—barren land. Painted Stork: E—wetland | F—agricultural land | G & H—barren land. © Sony.

Bhawnani et al. 2025), these findings are supported by the current study. Because of anthropogenic activities and the way this species behaves in its natural habitat, it has been determined that these activities are causing storks to shift their eating habits more frequently, which raises the energy requirements for flying and food search (Prabhakar & Dudhmal 2016). Due to increasing agricultural usage and monsoon failure, the wetland's water supply has become unstable in recent years, posing a major threat to the ecosystem. The area around it is largely degraded due to heavy cultivation and grazing (Anjali & Rana 2022). Since a substantial tract of agricultural land borders Haryana, it is subject to the strain of human activity. Therefore, to maintain a healthy ecosystem, such areas must be protected (Gulati & Rana 2022). The present study supports previous research on storks' susceptibility to habitat loss and human disturbance, but they also draw attention to the underappreciated function of agricultural landscapes as alternative habitats. The need for species-specific conservation measures is highlighted by the different habitat preferences found for Painted Stork and Woolly-necked Stork. Stork populations can be supported by preserving habitat variability, which is essential to their existence, while also encouraging sustainable agriculture practices and protecting wetlands. This study offers fresh perspectives on Dighal Wetland's seasonal population dynamics, habitat flexibility, and human-mediated habitat use. Although continuous anthropogenic concerns require ongoing monitoring and habitat management, local populations, especially of Painted Storks, may be bigger and more resilient than previously reported.

CONCLUSION

The Painted Stork and Woolly-necked Stork at Dighal Wetland exhibit distinct habitat preferences, which are reflected in their population patterns across the study area. Painted Storks were mostly recorded in higher numbers around open wetland zones such as large waterbodies and Jheel areas, where they find suitable conditions for foraging and feeding. In contrast, Woolly-necked Storks were more commonly observed in smaller numbers along agricultural margins, particularly in ditches, canal edges, and flooded crop fields. This difference in habitat use likely reduces direct competition between the two species and helps explain the variation in their local population distribution, shaped by their differing ecological needs and foraging behaviours.

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